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Gas UNIT - READINESS ASSESSMENT QUIZ (RAQ)
THIS QUIZ WILL BE PACED WITH CLICKER QUESTIONS

1. A 5.0 mol sample of Ne is confined in a 3.14 L vessel at a pressure of 2.5 atm. What is the number density of the gas? What is the mass density of the gas?

Number Density = #mol/L
Number Density = (5.0 mol)/(3.14L) = 1.6 mol/L

Mass Density = mass/L
We do not have the mass of the Ne gas sample yet! So we will have to do a conversion using the periodic table:

$$\frac{5.0 \text{ mol Ne}}{} \left| \frac{20 \text{ g Ne}}{1 \text{ mol Ne}} \right. = 100 \text{ g Ne}$$

Mass Density = (100 g)/(3.14 L) = 32 g/L

2. What is the total pressure of the gas mixture that contains?
0.267 atm He & 0.317 atm Ar & 0.277 atm Ne?

$P_{total} = P_{He} + P_{Ar} + P_{Ne}$ (Dalton's Law of Partial Pressures)
$P_{total} = 0.267 \text{ atm} + 0.317 \text{ atm} + 0.277 \text{ atm}$
$P_{total} = 0.861 \text{ atm}$

3. What is the mole fraction of Ar in a mixture that contains?
0.267 atm He & 0.317 atm Ar & 0.277 atm Ne?

$P_{Ar} = X_{Ar}P_{total}$
$X_{ar} = P_{Ar}/P_{total}$
$X_{ar} = (0.317\text{atm})/(0.861\text{atm}) = 0.368$ (Remember: mole fractions have no units!)

4. Think about marshmallow in syringe: Using macroscopic ideas of P, T and V and using the ideas from KMT explain the result of pushing in the plunger. In the description, include a picture of gas inside and outside marshmallow before and after plunger pushed in. Use the concept of velocity, pressure, collisions and molar mass of particles to explain the observed change.

- The temperature remains the same ***therefore*** the velocity of the particles remains the same
- The number and molar mass of the particles remain the same
- As the plunger is depressed, the volume decreases
- As the volume decreases, the space between the particles decreases inside the syringe so the number of collisions per square inch increases ***therefore*** the pressure increases

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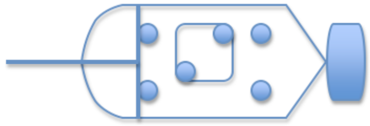
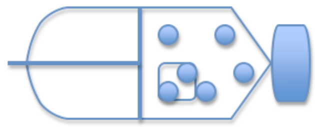
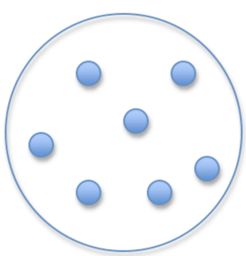
Pictures below: Before and After the plunger of the syringe is depressed



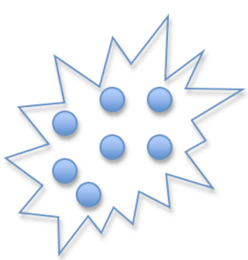


5. Think about the balloon in liquid N_2: Using macroscopic ideas of P, T and V and the ideas from KMT explain the result of putting the balloon in the liquid N_2. In the description, include a picture of gas inside the balloon before and after it is dipped. Use the concept of velocity, pressure, collisions and molar mass of particles to explain the observed change.

- The pressure inside the balloon remains the same (the balloon is always at constant pressure. It adjusts it volume to maintain a constant pressure because it is flexible)
- The temperature decreases
- The volume decreases as temperature decreases
- The number of gas particles and molecular weight of the gas particles remain the same



Comparing before and after the major change is the velocity of the gas particles. Because the temperature is lower, the velocity is lower. This means their collision have a smaller impact. **Therefore to maintain a constant pressure there must be more collisions**. This can be achieved if the volume decreases.



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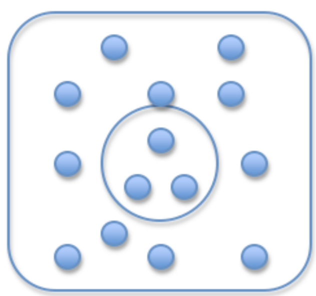
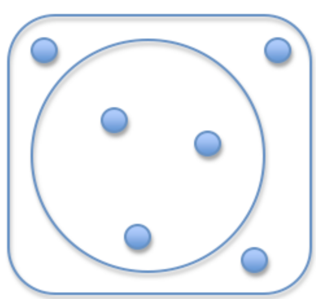
6. Think about the balloon in the vacuum chamber: Using macroscopic ideas of P, T and V the ideas from KMT explain the result of putting the balloon in the chamber and turning it on. In the description, include a picture of gas inside the balloon and outside the balloon before and after the pump is turned on. Use the concept of velocity, pressure, collisions and molar mass of particles to explain the observed change.

- The number of particles <u>inside</u> the balloon does not change
- The number of particles <u>outside</u> the balloon (but still inside the vacuum chamber) decreases
- The molecular weight of the particles does not change
- The temperature and therefore the velocity of the particles remain the same
- The volume of the balloon increases when the chamber is turned on
- When the vacuum chamber is turned on, the number of particles outside the balloon decreases ***therefore*** the number of collisions decreases ***therefore*** pressure outside the balloon decreases
- The collisions inside the balloon are greater than the collisions outside so the volume of the balloon increases against the low external pressure to create a “matching” low pressure inside (P and V vary inversely)

Pictures below: Before and After the vacuum chamber is turned on





Department of Chemistry
University of Texas at Austin

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7. You have two gases under identical conditions. One gas has a density that is double that of the other gas. What is the ratio of the rate of diffusion of the low-density gas compared higher density gas?

Our goal is to solve for the ratio of diffusion rates of a low-density gas compared to a high-density gas:

$$v_{low} : v_{high} \text{ which is the same ratio as } \frac{v_{low}}{v_{high}}$$

Key Idea: We assume that gases take up the same volume, so the differences in density must be due to a difference in MASS. **So the high-density gas has twice the mass as a low-density gas.**

$$m_{high} = 2m_{low}$$

Now we can use the equation for ratio of diffusion to compare the two rates:

$$\frac{v_{low}}{v_{high}} = \frac{\sqrt{\frac{3RT}{m_{low}}}}{\sqrt{\frac{3RT}{2m_{low}}}} = \sqrt{\frac{3RT}{m_{low}}} x \sqrt{\frac{2m_{low}}{3RT}} = \sqrt{\frac{2m_{low}}{m_{low}}} = \sqrt{2}$$

We substitute the mass of the high-density gas to be twice the mass of the low-density gas. The gas constant, R, and the temperature, T, cancel out (the gases were at identical conditions). So the final ratio between the rates of diffusion is the square root of 2.

8. Given the following reaction:

$$2CO + O_2 \rightarrow 2CO_2$$

Initially, you have a container with 2 moles of CO gas and 3 moles of O_2 gas at a constant temperature of 25°C and a constant pressure of 1 atm. What is the final volume after the reaction is complete?

This is a LIMITING REACTANT problem. There are several strategies for determining which reactant is the limiting reactant.

Conceptual strategy:

- For every 2 moles of CO that react, 1 mole of O_2 reacts and 2 moles of CO_2 are created.
- If we use up the 2 moles of CO that we are given in the problem, we would ONLY use up 1 mole of the O_2 according to the moles ratios we identified in the previous bullet point.

- Therefore, 2 moles of O_2 gas would be leftover and we would make 2 moles of CO_2!

Mathematical strategy:

- Divide the number of moles given in the problem by the molar coefficient from the reaction equation.

$$\frac{2\text{ moles CO}}{2} = 1 \qquad \frac{3\text{ moles } O_2}{1} = 3$$

- Compare the two results from above. The smaller number corresponds to the limiting reagent. Because 1 is less than 3, CO is the limiting reagent.
- We will use up ALL of the limiting reagent and only 1 mole of the O_2.
- Therefore, 2 moles of O_2 gas would be leftover and we would make 2 moles of CO_2!

Either strategy that you select, there will be a total of 4 moles of gas remaining in the reaction chamber (2 moles O_2 and 2 moles of CO_2). We will use the ideal gas law to determine the final volume. We assume that all the gases behave the ideally, so we can use the total number of gas moles as "n" in the ideal gas law equation:

$$PV = nRT$$

$$V = \frac{nRT}{P}$$

$$V = \frac{(4mol)(0.08206\frac{Latm}{molK})(298K)}{(1atm)} = 97.8L$$